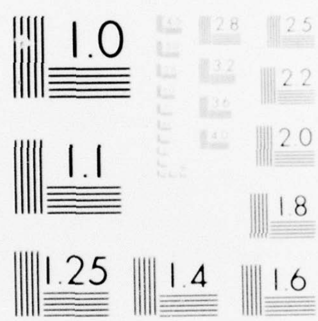
AD-A044 358 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 8/13
ENGINEERING AND SCIENTIFIC RESEARCH AT WES, JULY 1973.(U)
JUL 73

UNCLASSIFIED WES-MP-0-73-9 NL

| OF |

AD
A044358

END
DATE
FILMED
10-77
DDC




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ENGINEERING AND SCIENTIFIC RESEARCH AT WES

U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

Miscellaneous Paper 0-73-9 July 1973



# IN SITU ROCK MODULUS TESTING

*by J. B. Palmerton, Soils and Pavements Laboratory*

In situ deformation moduli of a soft sandstone formation were determined by both horizontal jacking tests performed in a 52-in.-diameter hand-excavated shaft and Menard pressuremeter tests performed in a 3-in.-diameter boring adjacent to the large shaft. Tests were performed at regular intervals at depths ranging between 10 and 100 ft.

The horizontal jacking apparatus, constructed at WES, is shown in fig. 1. It consists of a 500-ton hydraulic jack, support pads, and two annular flat jacks. The flat jacks serve to evenly distribute the applied load to the rock face. Each test setup results in two tests since the flat jacks bear on opposite sides of the 52-in. shaft. Deflections are measured at the face of the test surfaces and also at points behind the surfaces by means of potentiometers connected to rock anchors fastened in the instrumentation hole. Typical test results are shown in fig. 2. The nonlinear stress-displacement behavior of the sandstone is apparent from the figure.

The Menard pressuremeter tests consist basically of expanding a cylindrical membrane approximately 3 ft long into the walls of an NX borehole and measuring the resulting pressure-volume behavior. The equipment used was loaned to WES by the Construction Engineering Research Laboratory (CERL). These tests are relatively rapid to perform and should be especially useful for sites where laboratory samples are difficult to obtain. A typical test result from the pressuremeter is shown in fig. 3. From

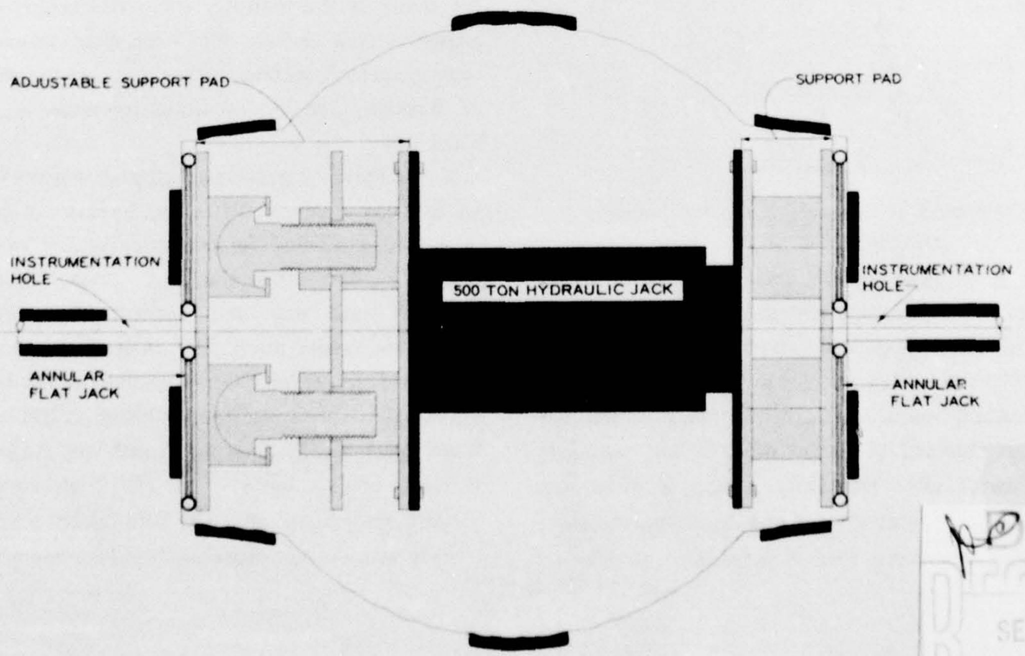



*Fig. 1. Horizontal jacking equipment*

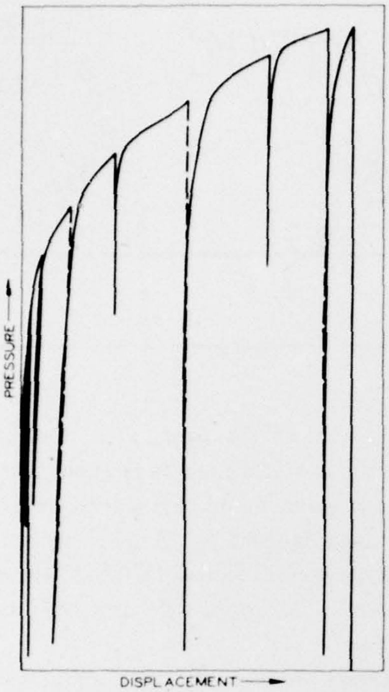



*Fig. 2. Typical pressure-displacement curve, horizontal jacking test*

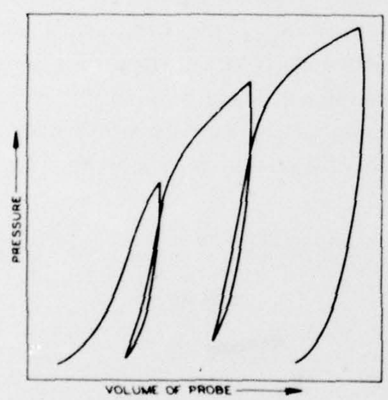



*Fig. 3. Typical pressure-volume curve, Menard pressuremeter tests*

these data it is possible to calculate the deformation modulus for various loading and unloading cycles.

The moduli values determined from the testing program will be used as input for predicting the behavior of a complex soil-structure interaction problem. In the case of structures founded in or on rock, in situ testing is especially useful since laboratory testing is often not adequate due to the limitations of sample size and sampling disturbance.

## A UNIFIED METHOD FOR DESCRIBING VEHICLE RIDE DYNAMICS

*by N. R. Murphy and A. S. Lessem, Mobility and Environmental Systems Laboratory*

In recent years, "speed made good" has come to be recognized as one of the most meaningful measures of the off-road mobility of a vehicle. Speed made good is simply the average speed that results when the straight-line distance between two points is divided by the time required to get from one point to the other, irrespective of the actual path taken by the vehicle. The maximum speed that a vehicle can attain in a given terrain is affected by the number and character of the terrain deterrents it must overcome or, if preferable, avoid. Terrain deterrents include soft soils, slopes, vegetation, obstacles, riverine situations, rough terrain, etc.

Experience has shown that one of the most significant single features influencing a vehicle's speed is that of ride dynamics, that is, the vibratory activity of a vehicle caused by terrain roughness. Since vehicle vibration is just one component of overall vehicle mobility, it must be described in a straightforward way. The description can then be easily used in its own right as well as to augment the evaluations of other components of mobility by comprehensive mobility models.

Efforts to quantify vehicle vibration and its effects practically and expediently have been frustrated by the complexity of the problem. The vibration environment is the result of the interplay of certain vehicle-terrain-man attributes that include the mechanical structure of the vehicle, spectral content and roughness of the terrain, speed of traversal, and the vibration tolerance of driver and occupants.

The Mobility and Environmental Systems Laboratory, U. S. Army Engineer Waterways Experiment Station, has developed a method for predicting vehicle vibration that considers the interaction of these factors in a straightforward way and presents the results in an easy-to-use graphic form. The method takes advantage of the fact that off-road terrain roughness can be classified into a relatively few categories based on spectral content. Within each category, terrain roughness can be classified in terms of root mean square (RMS) elevations. Vehicle properties are characterized by field-validated mathematical models with special attention given to nonlinear structural

elements. Human factors are included in terms of absorbed power—a measure of the vibrational energy absorbed by a human—and maximum acceptable accelerations. The method outputs a graph depicting, for a given vehicle and a given broad terrain type, response RMS accelerations and absorbed power as a function of terrain roughness and vehicle velocity. The graph, which is referred to as a TVS (terrain-vehicle-speed) graph, is easily used in vehicle design studies and in analytical models of overall vehicle mobility.

The steps involved in developing such a graph through analytical means are given below (see fig. 1):

a. Characterize the microgeometry of the terrain of interest by specifying the slope of the power spectral density (PSD) plotted on log-log coordinates. This slope is determined from a least squares fit of the data.

b. Characterize the vehicle of interest by assembling a lumped-parameter mass-spring-dashpot mathematical model reflecting the nonlinear mechanics of the vehicle.

c. Select a surface roughness in terms of root mean square (RMS) elevation; select a vehicle speed.

d. Use the PSD slope and RMS elevation to generate a random profile; use the vehicle speed to convert this profile into a time history.

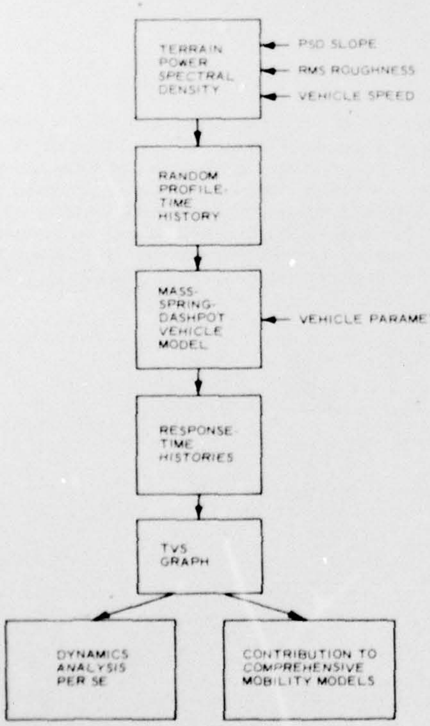



*Fig. 1. Determination of TVS graphs*

e. Use the profile-time history as a forcing function to generate vehicle and occupant response-time histories of interest. Use these time histories to determine statistical descriptors of interest, such as RMS acceleration at the driver's seat, distribution of acceleration amplitudes, and absorbed power.

f. Repeat steps c to e with different selections of terrain roughness and vehicle speed, and plot the computed statistic against the speed, thus defining a family of curves separated by the terrain roughness parameter. This is the TVS graph, an example of which is shown in fig. 2.

Such graphs completely define the ride dynamics characteristics for a vehicle operating in a given terrain type. Having once established certain vibration severity limits in terms of the maximum tolerable absorbed power or RMS acceleration, the TVS graph can be used to construct a ride-limiting-speed graph (fig. 3), which depicts

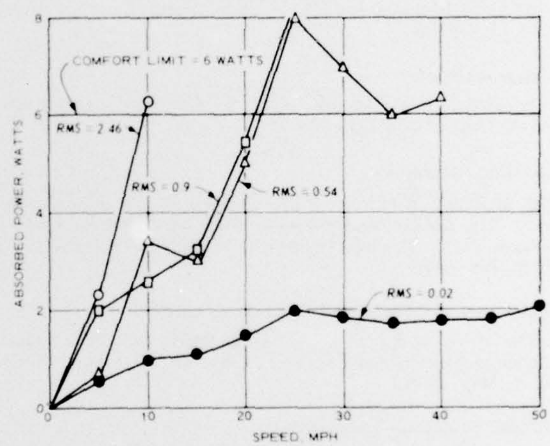



*Fig. 2. TVS graph showing driver absorbed power versus speed for the M35A2, 2-1/2-ton truck*

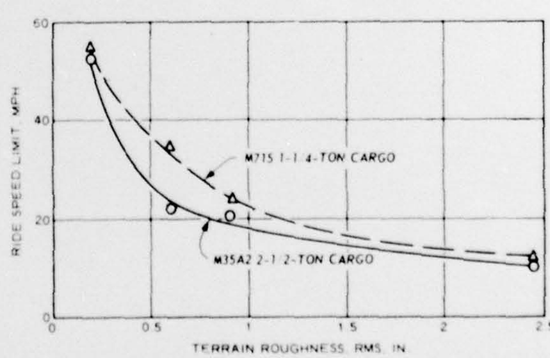



*Fig. 3. Ride limit speed graph obtained from TVS graph by plotting speed at 6 watts versus terrain roughness*

the maximum speeds permitted by ride limits as a function of terrain roughness. These TVS and ride-limit graphs could just as well be constructed from actual field test data in a manner similar to that used in the analytical development.

These graphs have three principal uses. First, they can be used in comprehensive models of ground mobility where ride dynamics is but one contributor to the operations environment of the vehicle. Such comprehensive models are quite elaborate and would be seriously encumbered by having to cope directly with the statistical processing necessary to evaluate the ride dynamics contribution. This processing, therefore, is done separately and cataloged for each vehicle. The results are accessed from the vehicle catalog files upon proper command to the computer and reported to the comprehensive model in the form of TVS and ride-limit graphs. Second, they can be used in design studies where the effects of component modifications, such as suspension alterations, redistribution of mass, etc., are displayed on a single graph covering broad ranges of roughness and speed. Third, this graphic scheme provides the military planner with a means for rating vehicles, on a standard competitive basis of ride, as to their capability to negotiate cross-country terrains at various speeds.

★ ★ ★ ★ ★

REPORTS RECENTLY PUBLISHED BY WES

*Office of Dredged Material Research:*

Feasibility Study of Hydrocyclone Systems for Dredge Operations, by W. G. Tiederman and M. M. Reischman, Contract Report D-73-1, Jul 1973.

*Concrete Laboratory:*

Multiaxial Creep in Concrete, by J. E. McDonald, Miscellaneous Paper C-73-6, May 1973.

*Hydraulics Laboratory:*

Study of Beach Widening by the Perched Beach Concept, Santa Monica Bay, California; Hydraulic Model Investigation, by C. E. Chatham, Jr., D. D. Davidson, and R. W. Whalin, Technical Report H-73-8, Jun 1973.

*Mobility and Environmental Systems Laboratory:*

Analysis of the Ability of a Laser Profilometer System to Evaluate Unprepared Landing Sites, by L. E. Link, Jr., Miscellaneous Paper M-73-7, May 1973.

*Soils and Pavements Laboratory:*

Analysis of Stress and Strain Distributions in Triaxial Tests Using the Method of Finite Elements, by N. Radhakrishnan, Technical Report S-73-4, May 1973.

*Weapons Effects Laboratory:*

Influence of Backfill Properties on the Collapse of Pipes under Dynamic Loads, by J. L. Drake and C. E. Joachim, Technical Report N-73-5, Jul 1973.

*Automatic Data Processing Center:*

A Computer Program for Lock Culvert Frame Analysis, by P. K. Senter and F. T. Tracy, Miscellaneous Paper K-73-5, Jun 1973.

*Explosive Excavation Research Laboratory:*

Military Engineering Applications of Commercial Explosives: An Introduction, by J. Briggs, Technical Report E-73-2, May 1973.

*Engineering and Scientific Research at WES* is published by the Waterways Experiment Station (WES), Vicksburg, Mississippi, to acquaint U. S. Government agencies and the research community in general with the many-faceted types of engineering and scientific activities currently being conducted at WES. Inquiries with regard to any of the reported specific subjects will be welcomed, and should be addressed to respective authors, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Mississippi 39180.